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Vital Phosphate Solubilising Microbes For Sustainable Agriculture

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Introduction

Phosphorus (P) is a macronutrient that plays an essential role in plant growth and participates in many metabolic reactions. It is a vital element for life as it is present in biological molecules, including nucleic acids, coenzymes, phosphoproteins, and phospholipids**.**Soil microbes mediate several biochemical reactions and thus act as a sink and source of Phosphate (P) in soil. The phosphate solubilizing microorganisms (PSM) are the important contributors to soil P pools which constitute 0.4% to 2.4% of total P in arable soils. Phosphorus solubilization is carried out by a large number of saprophytic bacteria and fungi acting on sparingly soluble soil phosphates, mainly by chelation-mediated mechanisms. Phosphate solubilizing microorganisms (PSMs), a large microflora that mediates bioavailable soil P, play a critical role in the soil P cycle by mineralizing organic P, solubilizing inorganic P minerals, and storing large amounts of P in biomass. By releasing phosphatase enzymes and organic acids, reducing soil pH, and increasing chelation activities with additional P adsorption sites, PSMs can dissolve soil P into soluble and plant available orthophosphate forms (mostly PO_4^{3-}, HPO_4^{2-}, and $H_2PO_4^-$).The low levels of phosphorus are due to the high reactivity of soluble phosphate with other elements. For instance, in acidic soils, phosphorus is associated with aluminum and iron compounds, whereas calcium phosphate is the predominant form of inorganic phosphate in calcareous soils.The use of microbial inoculants (biofertilizers) including PSM in agriculture represents an environmentally friendly alternative to further applications of mineral fertilizers. Phosphate-solubilizing microbes have the potential to increase the availability of soluble phosphate. Their activity enhances plant growth by increasing the efficiency of biological nitrogen fixation or enhancing the availability and crop uptake of other trace elements like iron, zinc, etc., and also by producing

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plant growth-promoting regulators.Phosphate SolubilizingMicroorganisms technology improves the fertility and agricultural use of saline-alkaline soil withoutcausing any environmental or health hazard that accompanies the continuous use of synthetic fertilizers. *Kushneria sp*. YCWA18, a strain that is capable of solubilizing both inorganic phosphorus and organo-phosphorus has also demonstrated moderate halophilic properties and can be used in the development of saline-alkaline-based agriculture **(Zhu et al.,2011).**

Role of Different Psm in Agriculture

Several Soil microbes i.eseveral bacteria, fungi, and a few species of actinomyceteshave the potential to bring insoluble phosphate in soil into soluble forms by secreting organic acid.

Bacteria: Bacteria are unicellular, prokaryotic, the microscopic organism usually devoids of chlorophyll and generally reproduced by fission. The population of bacteria varies from 10^8 to 10^9 cfu/g soil and biomass varies from 3000 to 4000 kg/ha**.** Bacteria are more effective in solubilizing insoluble phosphate compared to fungi. Among the different microorganisms, phosphate solubilizing bacteria (PSB) constitutes 1 to 50% of the whole population.they are the primary agent for biochemical cycles of C,N,P,S and release nutrients in soil from organic to plant-available forms. Among the different bacterial communities, *Bacillus* and *Pseudomonas*are the effective phosphate solubilizers. The major strains from bacterial genera are *Bacillus megaterium, B. circulans, B.subtilis, B.polymyxa, B. sircalmous, Pseudomonas striata*, and *Enterobacter*. Research studies have proved that PSB like *P.putida, P. fluroescens*etc used in conjunction with single super phosphate (SSP) and rock phosphate can reduce P dose by 25 and 50%. Application of bacterial inoculants **as biofertilizers** improves plant growth, plant-available P, increase yield, and also releases indole acetic acid and gibberellic acid that cause growth and elongation of a plant cell.

Fungi: fungi are uni to multicellular, unito multinucleate, filamentous, heterotrophic organisms usually reproduced by spores.they are active in the decomposition of cellulose and lignin. Fungi are the second most important phosphate solubilizingmicroorganisms. They constitute about 0.1 to 0.5% of the whole microbial population as P solubilizers. Compared to bacteria they do not lose their P dissolving activity upon repeated sub culturing under laboratory conditions. The P solubilizing fungi produce more acids than bacteria andtherefore exhibits more P solubilization activity. Fungi in soils can traverse long distances than bacteria

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are more important in P solubilization. Among the different fungi genera *Aspergillus sp., Penicillium sp., Trichoderma sp., Mucor sp., Rhizocotoniasolani*etc are the most promising strains of P solubilizers.Among the yeasts, *Yarrowislipolytica*, *Schizosaccharomyces pombe* and *Pichiafermentans*can solubilize P. These fungi are known to increase plant growth by 5 to 20%.

Actinomycetes: Actinomycetes areunicellular ,prokaryotic organisms with ray-like filaments. This group is transitional between bacteria and fungi.they take active participation in the decomposition of resistant compound like starch,inulin,chitin,paraffin, phenol, and pyrimidine, etc.Actinomycetes such as *streptomyces*, give soil its "earthy smell"Among the total population, 20% of actinomycetes are known to solubilize P. the common genera include*Streptomyces* and *Micromonospora.*

Arbuscular mychrozzial fungi (AMF): Generally used as biofertilizer @ 200gm of Packet for 10 kg seed.Arbuscular mychrozzial fungi (AMF) colonize almost all the crop species in agriculture and exploit a larger volume of soil for P uptake in P deficient soil. The microbial inocula consist of AMFs *Glomus manihotis*and *Entrophosporacolombiana*. Positive response with the application of phosphatic biofertilizers like phosphate solubilizingmicroorganisms (PSM) and VAM increases the solubility of nativeP and applied P. In general PSM constitutes 0.5 to 1.0% of soil microbial population with bacteria outnumbering fungi (2-150 fold). The crop species, in extremely low available soil P, develop root clusters effective in capturing P by releasing root exudates like organic anions, enzymes, phenolic acids, and protons. The use of inoculants, AMF, and plant growth-promoting microbes play a significant role in phosphate mineralization from both organic and inorganic sources. Generally used as a biofertilizer

Table 1: Biodiversity of PSM

Bacteria:*Alcaligenes sp., Aerobactor aerogenes, Achromobacter sp., Actinomaduraoligospora, Agrobacterium sp., Azospirillum brasilense, Bacillus sp., Bacillus circulans, B.cereus, B.fusiformis, B. pumils, B. megaterium, B.mycoides, B. polymyxa, B. coagulansB,.chitinolyticus, B. subtilis, Bradyrhizobiumsp.,Brevibacterium sp., Citrobacter sp., Pseudomonas sp., P putida, P. striata, P.fluorescens, P. calcis, Flavobacterium sp., Nitrosomonas sp., Erwinia sp., Micrococcus sp.,Escherichia*

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intermedia, Enterobacter asburiae, Serratia phosphoticum, Nitrobacter sp., Thiobacillus ferroxidans, T. thioxidans,Rhizobiummeliloti, Xanthomonas sp.
Fungi :*Aspergillus awamori, A. niger, A. tereus, A. flavus, A. nidulans, A. foetidus, A. wentii. Fusarium oxysporum, Alternaria teneius, Achrothcium sp. Penicillium digitatum, P balaji, P. funicolosum, Cephalosporium sp. Cladosprium sp., Curvularialunata, Cunnighamella, Candida sp., Chaetomium globosum, Humicolainslens, Humicolalanuginosa,Paecilomycesfusisporous, Pythium sp., Phoma sp., Populosporamytilina, Myrothecium roridum, Morteirella sp., Micromonosporasp.,Oideodendron sp., Rhizoctonia solani, Rhizopussp., Mucor sp., Trichoderma viridae, Torula thermophila,Schwanniomyces occidentalis, Sclerotium rolfsii.*
Actinomycetes: *Actinomyces,, Streptomyces*
Cyanobacteria: *Anabena sp., Calothrix braunii, Nostoc sp.,Scytonema sp.,*
VAM :*Glomus fasciculatum.*

(Adapted from Sharma et al., 2013)

Future Prospects

The use of PSM as biofertilizers will likely improve their use, as effective and important components in the establishment of sustainable soil management systems. The focus of consumers of agricultural produce is on the health, quality, and nutritional value of those products. Thus, the employment of PSM as biofertilizers is an option that can increase food production without imposing any health hazards, and at the same time conserve the environment. It is essential that researchers continue to learn more about PSM and, immediately, translate this knowledge into a form that can readily be used by farmers.

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